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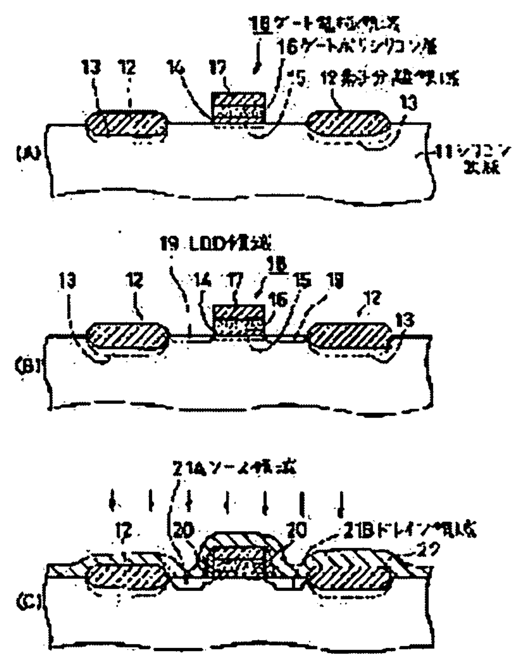
(54) HEAT TREATMENT METHOD FOR SEMICONDUCTOR SUBSTRATE

(57)Abstract:

PURPOSE: To provide a heat treatment method by which the defects in close proximity to the junction boundary of the shallow impurities diffusing area of a semiconductor substrate can be eliminated and besides the expansion of the junction.

CONSTITUTION: After an LLD region 19, a source region 21 A and a drain region 21B are formed in a silicon substrate 11, a ruby laser beam of 600mJ/cm2 is applied thereto and then an XeCl laser beam of 700mJ/cm2 is applied, thereby repairing a point defect caused by ion implantation and at the same time activating ions.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the manufacture approach of a semiconductor device, and relates to the semi-conductor manufacture process equipped with the peculiar annealing treatment for activating the crystalline recovery of a semi-conductor substrate and the carrier after an ion implantation especially.
[0002]
[Description of the Prior Art] In the production process of various semiconductor devices, in order that two or more semiconductor devices may be formed on the same semi-conductor substrate and may separate or connect semiconductor devices, various kinds of heating-at-high-temperature processings are performed. Moreover, ion-implantation processing is performed for formation of the LDD (Lightly DopedDrain) structure of a semiconductor device, or a source drain field, and in order to activate electrically after that the acceptor ion and donor ion of the crystallinity of a semi-conductor substrate which were recovered and poured in, activation annealing treatment is performed. Furthermore, the silicide layer which is a compound layer of refractory metals (W, Mo, Ti, etc.), a metal like Pt.Pd, and Si needs to be heating-at-high-temperature processed because of reduction of contact resistance. as such activation annealing treatment or heating-at-high-temperature processing -- the former and furnace annealing method and rapid thermal annealing (it abbreviates to RAT) -- law is adopted.
[0003] On the other hand, each semiconductor device is contraction-ized and shallow junction is needed in the source drain field, an emitter region, a base region, etc. as integration of a semiconductor device progresses. If activation annealing treatment is performed by the furnace annealing method or the RAT method to such a field, a diffusion layer becomes deep, junction of a source drain cannot be made shallow and demand of making a semiconductor device detailed and being integrated highly cannot be satisfied. Moreover, if it is an MOS transistor in connection with detailed-izing, gate length also becomes short, and since the diffusion layer which accomplishes a source drain field by the activation annealing treatment after an ion implantation extends not only to the depth direction but to a longitudinal direction, there is [a trouble that a punch-through becomes easy to happen]. In order to control the escape of such a diffusion layer and to make junction of a source drain shallow, temperature of activation annealing treatment must be made low and the problem on which resistance becomes high in this case, a current drive property falls to, and the switching characteristic of a transistor gets worse arises.
[0004] Then, the activation annealing method for performing a pulse laser exposure as an approach of forming the impurity diffusion field of shallow junction is proposed.
[0005] Since the energy of this pulse laser is absorbed on the **** front face (about 20nm) of a semi-conductor substrate, even if the depth in which annealing treatment is possible takes thermal diffusion into consideration by the pulse laser, it is about 100nm or less, and the temperature rise of the whole wafer is ******** or (about 1-2 degrees C). Therefore, the annealing treatment by the pulse laser is suitable for the activation annealing treatment at the time of formation of shallow LLD structure or a

source drain field.
[0006]
[Problem(s) to be Solved by the Invention] However, when the part of the bottom of the field of an ion implantation is deeper than the field by which annealing is carried out, there is a problem that junction leak will increase without carrying out annealing out of the defect enough. Although it is possible to make the power of laser increase and to anneal to a deeper field in order to solve this problem, there is a problem that the junction in a source drain field becomes deep. Moreover, when the power of laser is small, only the **** front face of a semi-conductor substrate fuses, and the front face of a semi-conductor substrate becomes flat immediately after that. However, when the power of laser is large, in order to fuse to the quite deep part of a semi-conductor substrate, there is also a problem that the surface smoothness of the front face of a semi-conductor substrate is spoiled remarkably.
[0007] This invention offers the heat treatment approach of a semi-conductor substrate that shallow junction can be formed in a detailed semiconductor device, and the junction leakage current of a transistor can be reduced, by being originated paying attention to such a conventional trouble, and using a pulse laser.
[0008]
[Means for Solving the Problem] Since the energy of a pulse laser is absorbed on the **** front face of a semi-conductor substrate, the above-mentioned problem originates in the temperature distribution over the depth direction of a substrate changing too much steeply.
[0009] Then, invention according to claim 1 makes it the solution means to irradiate the pulse laser from which two kinds of wavelength differs on said semi-conductor substrate front face, after forming an ion implantation layer with the shallow ion implantation depth in a semi-conductor substrate.
[0010] Invention according to claim 2 is characterized by performing the exposure of said pulse laser from a pulse laser with long wavelength to a pulse laser with short wavelength.
[0011] The pulse laser from which invention according to claim 3 differs in said wavelength is characterized by being the combination of ruby laser and XeCl laser.
[0012] After invention according to claim 4 forms an ion implantation layer with the shallow ion implantation depth in a semi-conductor substrate, it is characterized by irradiating the pulse laser of long wavelength, for the crystallinity of a semi-conductor substrate making it recover, irradiating the pulse laser of short wavelength subsequently, and activating the impurity of said ion implantation layer.
[0013]
[Function] In pulse laser annealing, although ruby laser (wavelength: 694nm), XeF (wavelength: 351nm), XeCl (wavelength: 308nm), KrF (wavelength: 249nm), ArF (wavelength: 193nm), etc. can be used, use of the combination of ruby laser and XeCl laser is promising especially. Two kinds of this laser changes in the depth to Si substrate absorbed with differences in wavelength.
[0014] That is, XeCl laser is absorbed on the **** front face of a substrate, and in order that ruby laser may reach to a part (about 1 micrometer) a little deeper than it, it is heated to a deep part. Therefore, it is possible to optimize the power of this two-kind laser and to control the temperature distribution over the depth direction coincidence or by irradiating continuously into the same part. In addition, drawing 2 is a graph which shows the relation between the photograph energy of various pulse lasers, and an absorption coefficient.
[0015] In fact, in order to activate the field by which the high concentration ion implantation was carried out, sufficient power is required for XeCl laser, and it is desirable 650 - 1100 mJ/cm2 and to make more preferably exposure energy at the time of XeCl laser annealing into 700 - 900 mJ/cm2. Moreover, 20 - 100ns of pulse width is desirable, and exposure spacing is arbitrary and good.
[0016] Although ruby laser is annealed to a deeper field, since activation annealing of the high concentration field near a front face is carried out by XeCl laser, the way with little power can prevent the redistribution of an impurity rather that removal of the comparatively low-concentration defect for an ion-implantation tail part is just performed.
[0017] In the heat treatment approach of the semi-conductor substrate of this invention, after forming a component isolation region and a gate electrode field, LDD and a source drain field are formed and

pulse laser processing by the combination of ruby laser and XeCl laser is performed. Since the temperature distribution of the depth direction can be made quiet distribution and annealing is carried out to a part deeper than the interface of junction by this, the junction leakage current of the diffusion layer formed in these fields can be reduced.
[0018] Since such pulse laser processing only affects it to the front face (for example, a depth of 100nm or less) of a semi-conductor substrate, shallow junction can be maintained to a source drain field, and it becomes possible to manufacture a detailed semiconductor device.
[0019] An important point is stopping the flare of junction to the minimum here, removing activation of the high concentration layer near a front face, and the defect near a junction interface by optimizing balance of the power of two kinds of pulse laser exposures.
[0020] And it is performing only heat treatment of 600 degrees C or less after the process of laser radiation. That is, it is because the junction in LDD structure or a source drain field will become deep if heat-treatment of 600 degrees C or more is performed after the pulse laser exposure process for activation of a source drain field. Although there is [******] sinter processing when forming an aluminum wiring layer when heat treatment is needed at a next process, the temperature needed in this processing is about 450-600 degrees C.
[0021]
[Example] It explains based on the example which shows the detail of the heat treatment approach of the semi-conductor substrate concerning this invention hereafter to a drawing.
[0022] (Example) Drawing 1 (A) - (C) is the important section sectional view showing the process of the example which applied this invention to manufacture of a MOS transistor.
[0023] First, the channel stop ion-implantation layer 13 under the component isolation region 12 and the component isolation region 12 is formed in a silicon substrate 11 using the well-known approach. Next, after forming gate oxide 14, the threshold voltage adjustment ion-implantation layer 15 is formed. And after covering gate oxide 14 in the gate polish recon layer 16, the silicide layer 17 is formed, as shown in drawing 1 (A), patterning of the silicide layer 17, the gate polish recon layer 16, and the gate oxide 14 is carried out, and the gate electrode field 18 is formed.
[0024] Next, as shown in drawing 1 (B), the ion implantation of the LDD (Lightly Doped Drain-souce) field 19 is carried out, and it is formed.
[0025] Then, as shown in drawing 1 (C), the side spacer 20 is formed in the side attachment wall of a gate electrode using the well-known approach, and, subsequently to source field 21A and drain field 21B, ion-implantation processing is performed. In the case of arsenic (As+) ion, this ion-implantation processing can set placing conditions to 5 - 20keV, and can set a dose to 1x1015 to 3x1015-/cm2. Moreover, in the case of BF2+ ion, the impregnation conditions 5 - 20keV, and a dose can be set to 1x1015 to 3x1015-/cm2.
[0026] Subsequently, as shown in drawing 1 (C), the ion poured into the LDD field 19 and source field 21A, and drain field 21B is activated by forming an oxide film 22 in 50nm thickness by the chemical-vapor-deposition method as an antireflection film if needed, and irradiating a pulse laser after that at a silicon substrate 11. The activation annealing treatment by this pulse laser irradiates the XeCl laser of short wavelength (308nm) with the exposure energy of 700 mJ/cm2 from ruby laser, after irradiating the ruby laser which is a pulse laser of long wavelength (694nm) first with the exposure energy of 600 mJ/cm2.
[0027] A next process completes a semiconductor device according to the manufacture approach of the conventional semiconductor device. In addition, in subsequent processes, it is important for a semi-conductor substrate to perform only heat treatment of 600 degrees C or less.
[0028] In this example, the point defect produced when ion was driven in to source field 21A and drain field 21B comes out by ruby laser exposure, and decreases effectively. Therefore, a point defect can be reduced effectively, without making junction deep by performing a ruby laser exposure. When such a pulse laser exposure is performed, reverse leakage current can be controlled. And since XeCl laser radiation performs activation of source field 21A and drain field 21B, shallow junction can be maintained, and the very-high-speed integrated circuit which consists of a detailed transistor can be

formed.

[0029] As mentioned above, although the example was explained, various kinds of design changes which are not limited to this and accompany the summary of a configuration are possible for this invention, and its combination other than the above is possible also for a pulse laser.

[0030] Moreover, although the above-mentioned example applied this invention to the MOS transistor, of course, applying to a bipolar transistor is also possible.

[0031]

[Effect of the Invention] According to this invention, it is possible to stop the flare of junction to the minimum, removing activation of the high concentration layer near a front face, and the defect near a junction interface by optimizing balance of the power of two kinds of pulse laser exposures. Therefore, a diffusion layer with little junction leak can be acquired, low resistance and shallow junction can be maintained, and the very-high-speed integrated circuit which consists of a detailed transistor can be formed.

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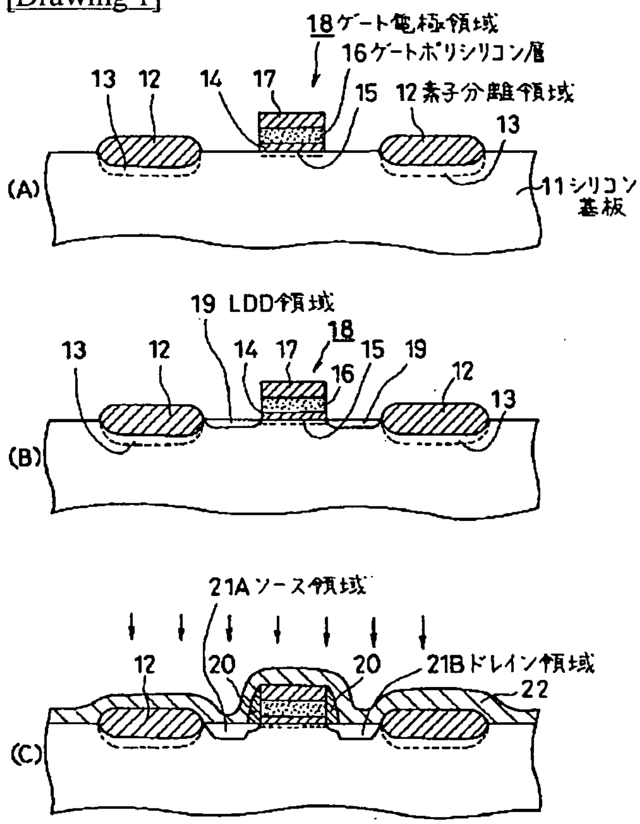
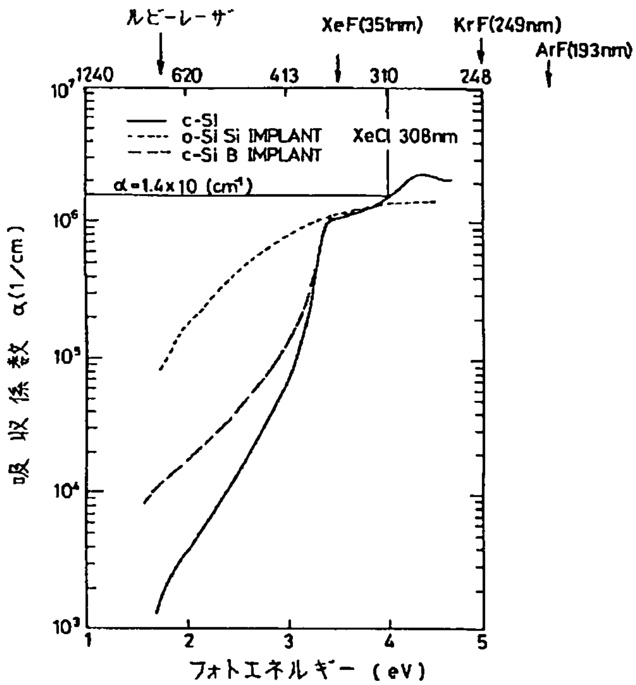
DRAWINGS

[Drawing 1]



[Drawing 2]



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